Novel Thermoelectric Material Design – High Thermal Conductivity Ringlets of Tapered Density Embedded Within Low Thermal Conductivity Metal

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Introduction

Traditional thermoelectric materials are predicated upon a design consisting of two layers composed of two materials, one of which is meant to be the “hot” side and the other of which is comparatively cool. As heat flows toward the cool side, electricity is generated through torsional stress between the layers. This approach is not entirely efficient and requires substantial amounts of heat.

In this author’s publication of 18 November 2023, a concept was introduced which recommends converting heat in a material of macro-uniform temperature into sound in the context of conditionally thermally insulative, electrically conductive elastomer structures. While there are many potential approaches which may be effective, including that which was proposed in the 18 November 2023 publication, it may be helpful to further explore the topic and another potential approach to bringing about thermoelectric effects in bespoke materials, particularly as these elastomer structures are prone to wear over time to a greater extent than originally anticipated.

Abstract

I propose that provided that a series of micro-scale ringlets composed of a high-thermally conductive material such as aluminium are incorporated into a low-thermally conductive material such as stainless steel, a heat-to-sound conversion effect may be realized with allows for materials which, although they are of a uniform temperature at the micro-scale, will naturally tend toward an unequal temperature at the -micro scale due to the conversion of heat into sound and sound into electricity. Its specifics are as follows:

In most materials, the overall material tends toward a state of thermal equilibrium or homeostasis. However, in a meta-material of a specialized nature, a material may, by its nature, shift thermal energy a small distance from one side of a ring-shaped boundary to another even when surrounding thermal conditions are unchanged. In the process of so doing, electricity would be generated which would, strictly speaking, first enjoy conversion from heat into sound before being converted into electricity.

The ringlets would be composed of a highly thermally conductive B-material such as aluminium which would stand in contrast to the surrounding material, which would be of minimal thermal conductivity. For the purposes of this proposal, let’s say that our A-material is stainless steel, as this is poor conductor of heat. Naturally disordered thermal motion would be unified into more synchronized molecular motion which would have as its average focus the interior of the rings. The consequence would be that heat would be conducted into the spaces at the interior of the rings (as acoustic energy)

during the first half of a two-step cycle and the ringlets would become comparatively cold as a consequence. The interior space of the rings would also be composed of stainless steel, but as I will explain, there is no taper at the boundary between the aluminium rings and the interior stainless steel. As a consequence of the ultra-efficient conduction of thermal-acoustic energy into the ringlet interiors, also composed of stainless steel, the interiors become substantially warmer than the surrounding area and in the second step in the two-step cycle, this heat is converted into torsional energy which is also convertible into (as is the acoustic energy) which is promptly converted into electricity, resulting in the net cooling of the overall material but also resulting in the production of electricity. The second phase in the two-step cycle would entail excess heat being drawn away from the interior stainless steel islands and some brief periods in which these islands would be cooler than the bulk of the stainless steel, but never colder than the aluminium.

Importantly, the B-material would, in order to achieve the desired effect, need to be gradated in terms of its density (and therefore its thermal conductivity) as such a property would be required at the junction between the low-conductor and the high-conductor at the exterior of the rings. At the interior boundary, as we want that acoustic energy to convert into electricity rather than continuing to flow as either heat or sound, there would be no taper or gradation of density, but rather direct contact between the densified aluminium and the stainless steel. The taper zone, located at the exterior of each of the ringlets, would feature a gradient of density in which thermal conductivity increases from that of something less than that of aluminium (as close as possible to that of stainless steel,) to that of aluminium and, ultimately, to a value even greater than that of standard aluminium at a specific rate which brings about the desired synchronization of oscillations associated with heat and consolidates those oscillations into acoustic energy. The slope of this gradient would be absolutely critical and it is only through experimentation that we could determine the proper thermal conductivity gradient needed to bring about a heat-to-sound conversion. This ideal gradient would best be ascertained by alloying the aluminium ringlets with the surrounding stainless steel through a melting point feathering technique which allows for the ratio of aluminium to stainless steel to be gradually tapered from sparse at the external boundary to increasingly pure as one moves toward the bulk of a ringlet. Aluminium’s natural thermal conductivity may be further enhanced through artificial densification, particularly at the interior diameter of the ringlets by means of performing the entire fabrication process inside of a large autoclave which is constantly increasing ambient pressure whereas the interior of each of the aluminium rings is made to be the last to solidify as cooling transpires, resulting in materials which vary in density depending upon when solidification occurred in the context of an autoclave pressurization cycle. This manufacturing process would simply require that a sheath-shaped LASER light be used to heat the aluminium to its own melting point (much lower than that of stainless steel) so that solidification of the metal happens gradually from the outside, in. As this solidification transpires (LASER power is gradually reduced to allow cooling) the interior portions of the rings solidify at a later time when ambient pressure is higher producing ringlets which are substantially more dense and, therefore, more thermally conductive as one approaches the interior diameter of the rings.

It is interesting to note that provided that we use a method of manufacture in which thermal variation is introduced in the process of manufacture of such a thermoelectric mechanism, we create a mechanism in which it is no longer necessary for thermal gradients to be continually present on the -macro scale in order for the overall mechanism to generate energy, given the unique structural configuration.

Conclusion

Such a configuration of materials should be capable of unprecedented thermoelectric efficiency and unlike the material proposed in 18 November 2023, should not be subject to wear due to repeated breaking of molecular bonds in elastomer layers. This mechanism does not call for any elastomers. Such a mechanism would have as a unique characteristic that it is innately cold; perhaps extremely so. It would remain so without the introduction of any electrical energy, contrasting with the sort of thermoelectric compounds currently used in solid-state cooling systems. Such mechanisms may prove essential for facilitating future electrical generation schema.